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RESPONSE OF GRAPE ROOTSTOCKS TO DIFFERENT LEVELS CHLORIDE SALTS

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ABSTRACT

A Pot culture experiment was conducted at Grape Research Station, Rajendranagar, Hyderabad to study the variability in salt tolerance of grape rootstocks (viz., Dogridge, Salt Creek, RS-19, SO4 and 1613-C) to different chloride salts viz NaCl, KCl, $MgCl_2$ and $CaCl_2$ salts) under varying levels of salinity treatments (control, 4meq, 8, 16 and 32 meq/lt.). The experiment was laid out in a FCRBD with three replications. The relative salt tolerance was assessed based on growth parameters, dry weight of root to shoot ratio, percent reduction in growth parameters, days taken for manifestation of scorching symptoms, K/Na ratio and also on the ability of rootstocks to limit uptake of Na and Cl ions. Among different concentrations of chloride salts, significantly higher growth parameters were observed with control treatments followed by progressive decrease with increase in concentration of chloride salts. The interaction effect was significant in average number of roots and root to shoot ratio. Among Cl^- salts minimum percent reduction in growth parameters was observed with $MgCl_2$ and $CaCl_2$ while maximum percent reduction in growth parameters was observed with NaCl, followed by KCl salts. 1613-C recorded the highest leaf K/Na ratio (14.05). However, it was on par with SO_4 (13.44), RS-19 (10.34). The least leaf K/Na ratio was recorded with Salt Creek (7.38), which was on par with Dogridge (8.76). Concentration of Na^+ was lower (0.06%) in 1613-C and SO4 where as higher Na^+ content in leaf was observed in Salt Creek (0.10%) which was on par with Dogridge (0.09%) and RS-19 (0.08%). High chloride exclusion ability represents the salt tolerance. Significantly lowest chloride content was recorded with Dogridge (0.87%) rootstock whereas the highest chloride content was recorded with Salt Creek (1.14%) and was on par with other rootstocks. The application of CaCl2, MgCl2 and KCl salts did not have significant influence the uptake of Na+ ion. The Cl accumulation in leaf was significantly higher when applied in the form of NaCl followed by KCl and it was significantly lower when applied in the form of CaCl2 and MgCl2 salt. Among Cl- salts visual toxicity symptoms were observed earlier with application of NaCl, KCl salts followed by application of CaCl2 and MgCl2 salts. This might be because of among cations Na+ and K+ were more toxic than Ca and Mg. Among rootstocks, early in RS-19 followed by Salt Creek and Dogridge and it was late in SO4 and 1613-C. In all the rootstocks there was progressive decline in the growth parameters, root parameters, K/Na ratio, root to shoot ratio and increase in sodium and chloride content with the increase in concentration of chloride salts over control. Irrespective of salts and rootstocks to visual symptoms were observed earlier at higher concentrations The order of tolerance to chloride salts by grape rootstocks was in of the order CaCl2 >MgCl2 > KCl >NaCl salts. High innate vigour (high dry weight of root to shoot ratio and growth parameters) of Dogridge combined with high chloride exclusion ability represents the best combination for salt tolerance which however, could not be supported by low K/Na ratio. In case of 1613 C and SO4, the high K/Na ratio and late appearance of salt toxicity symptoms supported salt tolerance but less vigour and chloride exclusion were not in support relative to Dogridge.

KEYWORDS: Salt Tolerance, Root to Shoot Ratio & Toxicity Symptoms

Original Article

INTRODUCTION

Grape (Vitis spp) is one of the most commercially grown fruit crops in the world. Grapes are cultivated in an area of 111.4 thousand hectare with a total production 1,234.9 thousand tons in India (Shinde, 2016). Salinity is a serious concern in grape production, owing to moderates tolerant to saline environment. Salts are a natural component in soils and water. The ions responsible for salination are: Na^+, K^+, Ca^{2+}, Mg^{2+} and Cl^-. Among the strategies adopted for sustaining growth and productivity of vine cultivars under salinity use of tolerant rootstocks is widely accepted (Singh *et al* 1993). Susceptibility or tolerance of rootstocks to high salinity is a coordinated action of multiple factors. The salinity tolerance induced by rootstock is attributed to root system restricting the movement and or limiting absorption and accumulation of toxic ions from saline soils (Hepaksoyetal 2006, walker *et al* 2002). Plants generally vary in response to soil salinity and grapevine in particular have been defined as moderately sensitive to salinity (Downton 1977, Mass 1990). Physiological effects of exposure to salinity in grapevine include reduced stomatal conductance and photosynthesis (Ben-Asher *et al*.2006, Downton 1977) systemic disturbances can lead to reduced growth and vegetative biomass (Shani and Ben-Gal 2005) and yield Walker *et al*., 2002. Walker *et al*., 2004. Concluded that a high innate vigour of a rootstock combined with moderate to high chloride and sodium exclusion ability represents the best combination for salt tolerance. The very fact that there are marked differences of relative salt tolerance among the rootstocks but also there are differences in absorption of Cl ion when associated with different cations emphasizes the importance of this study. Hence, this study is aimed to determine the effects of different Cl salts (NaCl, KCl, $CaCl_2$ and $MgCl_2$) on the tolerance of grape rootstock measured in terms of growth parameters, dry weight of root to shoot ratio, sodium and chloride content in leaf.

MATERIALS AND METHODS

The present pot culture study was conducted at Grape Research Station, Rajendhranagar, Hyderabad during the year 2008-09. It is situated at an altitude of 530.38 meters above M S L and geographically lies at a latitude of 17^0 20’ N and longitude of $78^{o.}$25’ E. The treatments consisted of 20 treatment combinations with an objective to screen five rootstocks viz., Dogridge (*Vitis champini*), Salt Creek (*Vitis champini*), RS-19(Ramsey (*V. candicans* x *V. rupestris*) and Schwarzmann (*V. riparia* x *V. rupestris*)), SO4 (*Vitis berlandieri x Vitis riparia*) and 1613-C (*Vitis solonis x Othello*) against four chloride viz., NaCl, KCl, $CaCl_2$ and $MgCl_2$ salts applied at 4meq, 8, 16 and 32 meq/lt concentrations. The saline water was prepared by dissolving salts of NaCl, KCl, $CaCl_2$, and $MgCl_2$ in normal water with different concentrations as per treatments to get 4, 8, 16 and 32 meq of Cl /lt of water. The EC of prepared saline water was measured The experiment was laid out in a FCRB with three replications and three rootstocks in each replication. Six months old rooted cuttings of rootstocks were planted in earthen pots filled with red soil and well decomposed FYM mixed well in 3:1 proportion. The irrigation water (control) was neutral (pH 7.5), slightly saline (0.85 dSm^{-1}) with chloride (2 meq l^{-1}) and sodium (0.5 meq l^{-1}) levels below the threshold limit. It was safe with respect to residual sodium carbonate and sodium adsorption ratio. After the initial establishment, the rootstocks were irrigated with saline water prepared by mixing four different chloride salts (NaCl, KCl, $CaCl_2$ and $MgCl_2$) at different concentrations (4meq, 8, 16 and 32 meq/lt) in irrigation water for three months. The plants were irrigated with uniform volume of water below the field capacity. The soil used for pot filling was sandy clay loam in texture, low in organic carbon (0.35%), low in available nitrogen (225 kg ha^{-1}) and phosphorus (9.5 kg ha^{-1}), medium in potassium (154 kg/ha).The soil was neutral in reaction (pH 7.1) and non saline (EC 0.32 dSm^{-1}). Standard procedures were followed for analysis of soil (Jackson 1973) and water (Jackson 1973). Biometric observations per plant viz., number of roots (cm), root volume (cc), shoot length (cm), number of leaves, dry

weight of root (g) and dry weight shoot (g) were recorded at the end of the experiment. The root volume (cc) was measured by water displacement method. The leaves were collected from each replication and were washed and oven dried at 60^0C temperature. Sodium content in leaves was determined using flame photometer. Chlorides was determined by titration (Richard, 1968).

RESULTS AND DISCUSSIONS

Growth Parameters: The effect of different chloride salts concentrations on the growth parameters like leaf number, shoot length and dry weight of shoot of grape rootstocks are shown in Tables.

Average Number of Leaves per Plant: It is evident from the Table 1 that average number of leaves differed significantly with their concentrations. Control treatment recorded the highest number of leaves (88.08) and this was on par with 4 meq of Cl/lt i.w. This was followed by progressive decrease in number of leaves with increase in concentrations of chloride salts. The percent reduction in number of leaves over control was 11.36, 20.45 and 29.5 with 8, 16 and 32 meq of Cl /lt i.w. respectively. There was no significant interaction between rootstocks x salts, rootstocks x concentrations, salts x concentrations and rootstocks x salts x concentrations on average number of leaves.

Shoot Length (cm): control treatment i.e. normal irrigation water recorded significantly highest shoot length (93.1cm) followed by progressive decrease in length of shoot with increase in concentrations of chloride salts. Significantly lowest shoot length was recorded at highest level i.e. 32 meq of Cl/i.w. The per cent reduction in length of shoot over control was 14.7, 26.3, 35.2 and 48.9 per cent with 4, 8, 16 and 32 meq of Cl /lt i.w. respectively. (Table 2)

The interaction effect between rootstock and salts were found to be significant with regard to shoot length. The SO_4 receiving NaCl and KCl salts recorded maximum shoot length which was on par with RS-19 receiving $MgCl_2$ and $CaCl_2$ and also in Salt Creek and Dogridge receiving $MgCl_2$ and 1613-C x KCl treatment which were significantly superior to rest of the interactions. Least shoot length was recorded in Dog ridge receiving NaCl and KCl salts.

The interaction between rootstocks and concentrations was significant on shoot length. All rootstocks receiving normal irrigation water i.e control were on par with each other, except 1613-C in control which was on par with rootstocks receiving chloride salts at 4 meq of Cl/lt i.w. whereas 1613-C x 4 meq of Cl/lt i.w. was on par with Dogridge and Salt Creek receiving 8 meq of Cl/lt i.w. and RS-19 and SO_4 receiving 8 meq and 16 meq of Cl/lt i.w. Further the 1613-C receiving 8 and 16 meq of Cl/lt i.w was on par with RS-19 and SO_4 receives 16 and 32 meq of Cl/lt i.w. While 1613-C x 32 meq of Cl/lt i.w. was on par with Dogridge x 16 meq of Cl/lt i.w. and Salt Creek x 32 meq of Cl /lt i.w. Least shoot length was recorded with Dogridge x 32 meq of Cl/lt i.w.There was no significant interaction between salts and concentrations and rootstocks x salts x concentrations on shoot length.

Dry Weight of Shoots: It is evident from the Table 3 that the dry weight of shoots significantly differed due to concentration of chloride salts. Control treatment (44.34g) recorded maximum dry weight which was on par with 4 meq of Cl/lt i.w. (42.28g) salt concentration. This was followed by 8 meq of Cl/ lt i.w. (39.66 g) but was on par with 16 meq of Cl/lt i.w. (36.61g). Significantly lowest shoot weight (31.96g) was recorded at highest chloride concentration. The percent reduction in dry weight of shoot over control was 4.65, 10.55, 17.43 and 27.92 with 4, 8, 16 and 32 meq of Cl /lt i.w. respectively. There was no significant interaction between rootstocks x salts, rootstocks x concentrations, and salts x concentrations and rootstocks x salts x concentrations on dry weight of shoot.

Root Growth Parameters

Average Number of Roots

Interaction between rootstocks and concentrations of chloride salts had significant impact on average number of roots (Table 4). The maximum number of roots was recorded with Dogridge in control followed by 4 meq of Cl/lt i.w. Further 1613-C in control and 4meq of Cl /lt i.w was on par with SO_4 and RS-19 in control. This was followed by Dogridge x 8 meq/lt i.w,.Salt Creek x control and SO_4 x 4 meq of Cl/lt i.w. with no significant difference among themselves. Further RS-19 and Salt Creek receiving 4 meq of Cl/lt i.w. were on par with each other. Dogridge x 16 meq of Cl/lt i.w. was on par with other rootstocks receiving 8 meq of Cl/lt i.w. While 1613-C, SO_4 and RS-19, Salt Creek receiving 16 meq of Cl/lt i.w. each were on par. The minimum number of roots was recorded with highest concentration of 32 meq of Cl/lt i.w in all rootstocks. The interaction between rootstocks x salts, salts x concentrations and rootstocks x salts x concentrations was found to be non significant.

Average Length of Root: It was shown in Table 5 that control treatment i.e. normal irrigation water recorded significantly highest average length of root (60.4cm) and lowest was recorded in maximum concentration of salts. The significant decrease with increase in concentration of chloride salts was observed. The per cent reduction in length of root over control was 13.16, 30.6, 48.48 and 74.38 per cent with 4, 8, 16 and 32 meq of Cl /lt i.w. respectively.The interaction effect between rootstocks x salts, rootstocks x concentrations, salts x concentrations, and among rootstocks x salts x concentrations on average length of roots was found to be non significant.

Among different concentrations of chloride salts, all the growth characters were significantly higher with control treatments followed by progressive decrease in shoot and root growth characters with increase in concentration of chloride salts. Sinel nikova *et al.* (1972) who stated that increase in salinity levels caused decrease in plant hormone content (Auxin and Gibberellin) and increase in inhibitors level which restricted the growth and subsequent rooting. While Levitt (1974) explained that salinity caused decreased in DNA synthesis in grapes.

Root Volume: Control treatment i.e. normal irrigation water recorded the significantly highest root volume (156.5cc) followed by progressive decrease in dry weight of root with increase in concentration of chloride salts. The percent reduction in root volume over control was 15.9, 32.3, 47.0 and 64.5 per cent with 4, 8, 16 and 32 meq of Cl/lt i.w. respectively (Table 6). There was no significant difference between rootstocks x salts, rootstocks x concentrations, salts x concentrations and rootstocks x salts

Dry Weight of Roots: Control treatment i.e. normal irrigation water (32.14g) recorded significantly maximum root weight followed by progressive decrease in dry weight of root with increase in concentrations of chloride salts. The percent reduction in dry weight of roots over control was 19.2, 32.94, 46.08 and 67.05 per cent with 4, 8, 16 and 32 meq of Cl /lt i.w. respectively (Table 7).There is no significant interaction effect between rootstocks x salts, rootstocks x concentrations, salts x concentrations and rootstocks x salts x concentrations on dry weight of root (g).

Dry Weight of Root: Shoot Ratio

Control (0.7) and 4 meq of Cl salt/lt i.w. (0.6) was recorded highest dry weight of root: shoot ratio. This was followed by 8 (0.5) and 16 meq of Cl salt /lt i.w. (0.5) with no significant difference among themselves. The lowest dry weight of root: shoot ratio (0.3) was recorded with 32 meq of Cl salt/lt i.w.(table 8)

The interaction effect between rootstocks and salts was found to be significant. The highest dry weight of root: shoot ratio was recorded with Dogridge, Salt Creek, RS-19 and SO_4 in control. This was followed by 1613-C x control was on par with all rootstocks receiving 4, 8, and 16 meq of Cl salt/lt i.w.in Dogridge, RS-19 and SO_4. Further Salt Creek and 1613-C x 16 meq of Cl/lt i.w. was on par with all rootstocks receiving 32 meq of Cl/lt of i.w.

The dry weight root to shoot ratio decreased with increase in concentration of chloride salts. Similar results were reported by Thambe **(1999)** The decrease in dry weight of root to shoot ratio might be due to reduction in number of leaves and chlorophyll content resulting in lower rate of photosynthates being transported to roots or due to reduced phosphorus uptake leading to depressed growth because of less development of energy carrying ATP and decrease in rate of protein synthesis due to low nitrogen content (Hewitt, 1963).

Percent Reduction of Growth Parameters

Percent reduction in various growth parameters is an indicator of relative salt tolerance. Among Cl^- salts minimum percent reduction in growth parameters was observed with $MgCl_2$ and $CaCl_2$ while maximum percent reduction in growth parameters was observed with NaCl, followed by KCl salts.(Table 9) This result indicates Ca^{+2} and Mg^{+2} ions had less negative effect on growth than Na^+ and K^+. This might also be because of higher Cl^- content in leaf associated with Na^+ and K^+ than Ca^{+2} and Mg^{+2}. (Kishore *et al*. 1985). In case of NaCl higher percentage of reduction could be due to compounding toxic effect of both Cl and Na which cannot be differentiated. The salt effect on growth could be due to suppression of growth process requiring light, for example leaf expansion and the accompanying net synthesis of nucleic acid and proteins (Nieman and Poulsen, 1971).

Among the rootstocks with application of NaCl, the percent reduction in growth parameters was less with SO4 (17.0%) and 1613-C (17.1 %) and high with Salt Creek (21.9%). In case of KCl the lowest reduction was recorded in 1613-C (13.3 %) and highest-- was with SO4 (19.4 %). In respect of $CaCl_2$, lowest was with 1613-C (15.4 %) and highest with Dogridge (17.1 %). In case of $MgCl_2$ salt, the lowest reduction in growth parameters was recorded with Salt Creek (13.4 %) and highest with RS-19 (17.1 %).

With application of NaCl, among rootstocks the lowest reduction in root parameters was recorded with SO4 (32.73%), whereas highest was with RS-19 (40.95%).The lowest reduction due to KCl was recorded with 1613-C (31.8 %) whereas highest was with RS-19 (34.2%). In respect of $CaCl_2$, the lowest was recorded with SO4 (28.2 %) whereas highest was with Dogridge (33.4 %). In case of $MgCl_2$, the lowest per cent reduction in root parameters was recorded with 1613-C (26.1 %) whereas highest was with RS-19 (31.7 %). Among chloride salts, the reduction in root parameters was less with $MgCl_2$ (28.8 %), $CaCl_2$ (30.7 %) and it was high with NaCl (35.93%) and KCl (33.1%).

In case of salts, per cent reduction in root parameters was highest with NaCl followed by KCl compared to $CaCl_2$ and $MgCl_2$ salts. This trend was similar to that observed in case of shoot growth. Deshmukh *et al.* (2008) reported that the NaCl in the root zone adversely affected the grapevines by causing direct injury to roots rendering water unavailable to plant, by accumulation of toxic ions like chloride, deficiency of essential elements like potassium and phosphorus. Under salt stress loss of permeability in roots leads to unrestricted entry and accumulation of toxic ions, mineral salts and decrement in retention of nutrients. The reduction in root mass might be due to effect of salinity on growth and development processes in plants. Reduction in root density due to soil salinity has been reported by Pearson *et al*. (1957).

Leaf K/Na Ratio

The data pertaining to the leaf K/Na ratio as affected by rootstocks and concentrations of chloride salts is presented in (Figure 9). 1613-C recorded the highest leaf K/Na ratio (14.05). However, it was on par with SO_4 (13.44), RS-19 (10.34). The least leaf K/Na ratio was recorded with Salt Creek (7.38), which was on par with Dogridge (8.76). Vines receiving 4 meq of Cl/lt i.w. recorded the highest leaf K/Na ratio (18.48). The K/Na ratio in leaf decreased significantly with increasing concentration of chloride salts. However, K/Na ratio in leaf which was 11.6 and 7.95 at 8 and 16 meq of Cl/lt i.w. respectively was on par with each other. The least K/Na in leaf was recorded with 32 meq of Cl/lt i.w. (5.13).The interaction between rootstocks x concentrations was found to be non significant with regards to K/Na ratio in leaf.

As per Levitt (1974) higher the K/Na in leaves more is the salt tolerance. Samra (1986) stated that tolerance seems to be related to K/Na ratio in the leaf and not with absolute contents of sodium. It appears that there was excessive transportation of K^+ from root to aerial parts for coping up with sodium toxicity until there was breakdown in its translocation mechanism. Ayodi and Hamza (1984) compared tolerant and sensitive plants for transport of Na^+ and K^+ and found that in tolerant plants the Na^+ taken up from medium or soil solution is diverted into the vacuoles while K^+ taken up is diverted into the phloem, due to which the sodium salts do not take part in the metabolic activities. Similarly results have been reported by Alsaidi (1980) under saline conditions, where higher K/Na was found in the leaves of Dess- Aniz Cv. of grape indicating that it was relatively more tolerant.

Cation Composition in Leaf (Na^+)

There was significant difference among rootstocks in their cationic composition with application of different Cl salts. (Figure 5) Concentration of Na^+ was lower in 1613-C and SO_4 when compared to other rootstocks. Similar results were obtained by Shikhamany (1999) with the rootstocks Teleki, 5-A, St. George and 1613-C as compared to Dogridge, Tambe (1999) with Salt Creek as compared to Dogridge and 1616-C and Jagdev Sharma & Upadhyay (2008) with Dogridge as compared to B2-56 in reducing the Na^+ concentration in the petioles. Fisarakis *et al.* (2001) reported lowest Na^+ content recorded when sultana vines grafted on 110R and SO_4 rootstocks especially in roots as compared to 41-B, 1103P and 140 Ru rootstocks. Lal *et al.* (2007) reported that as general rule salt concentration of leaves increases more quickly in salt sensitive varieties than salt tolerant varieties. Application of NaCl recorded highest Na content in leaf (0.18%) when compared to application of other salts. There was no significant difference among other salts with respect to Na.

In general a significant increase in Na content in leaf was recorded at 32 meq of Cl salt /lt i.w (0.12%). This was by followed 16 (0.09%) and 8 meq of Cl salt/lt i.w. (0.07%) and was on par with each other. The lowest Na content in leaf was recorded in control (0.04%) but was on par with 4 meq of Cl salt/lt i.w. (0.05%) (Figure 6)

Chloride (Cl^-) Composition in Leaf

Salinity tolerance was also associated with their ability to exclude Cl^- In the present study there a significant effect of accompanying cation on chloride content in leaf. Higher chloride content in leaf was recorded with NaCl application followed by KCl, while lower chloride content was recorded with $CaCl_2$ and $MgCl_2$ which were on par with each other. It can be inferred that absorption of Cl^- was higher when associated with monovalent cations Na^+ and K^+ when compared to divalent cations Ca^{+2} and Mg^{+2}. High chloride exclusion ability represents the salt tolerance (Walker *et al.*,2003).

Significantly lowest chloride content was recorded with Dogridge rootstock. Whereas the highest chloride content were recorded with Salt Creek (1.14%) and was on par with other rootstocks (Figure 7). The most tolerant rootstocks are those capable of maintaining low Cl concentrations in either their own foliage or that of the scion (Alexander, Groot-Obbink, 1971; Downton, 1977a; 1977b) because salt-induced limitations in photosynthesis and stomatal conductance of grapevines are related to high Cl and not to Na contents in the leaves (Prior *et al*., 1992).Significantly highest Cl content in leaf (1.59%) was recorded with 32 meq of Cl/lt i.w. and was superior to rest of the Cl salt concentrations. This was followed by progressive increase in Cl content in leaf with increase in concentration of Cl salts. The lowest Cl content in leaf was recorded with control (Figure 8).

The interaction effect between salts and concentrations were found significant in respect of Cl content in leaf. The highest Cl content was recorded with NaCl (1.81%) but was on par with KCl (1.78%) at 32 meq of Cl/lt.i.w. This was followed by NaCl x 16 meq of Cl/lt i.w. was on par with $CaCl_2$ x 32 meq of Cl/lt i.w. Further KCl x 16 meq of Cl/lt i.w. was on par with $MgCl_2$ x 32, $CaCl_2$ x 16 and NaCl x 8 meq of Cl/lt i.w. While $MgCl_2$ at 8 and 16 meq of Cl /lt i.w. was on par with KCl, $CaCl_2$ at 8 meq of Cl /lt i.w. This was followed by 4 meq of Cl/lt i.w. of all salts and was on par with each other. Where control treatments were recorded significantly lowest Cl content in leaf. The interactions effect between rootstocks x salts, rootstocks x concentrations and among rootstocks x salts x concentrations was found to be non significant on Cl content in leaf.

However of the grapevine rootstocks rated as tolerant to salinity due to their ability to prevent Na and /or Cl uptake and translocation to aerial parts of the vines (Tregeagle *et al*.,2006). In the present study though the Dogridge rootstock recorded lowest chloride content it recorded higher Na^+ content in leaf. The results were supported Kuiper (1968) who also reported an inverse relation between chloride and sodium transport capacities by grape root lipids suggesting that rootstocks that transport chloride readily should restrict sodium transport and vice versa. There is often a negative correlation between Na^+ and Cl^- concentration in the leaves.

Days for Manifestation of Injury Due to Varying Levels of Chloride Salts in Different Rootstocks

Visual toxicity symptoms were observed earlier with NaCl, KCl application when compared to $CaCl_2$ and $MgCl_2$ in different rootstocks. (Table 10)

Among Cl^- salts visual toxicity symptoms were observed earlier with application of NaCl, KCl salts followed by application of $CaCl_2$ and $MgCl_2$ salts. (Plate 14 and 15). This might be because of among cations Na^+ and K^+ were more toxic than Ca and Mg as reported by Kishore *et al*. (1985).

Among rootstocks manifestation of injury with application of different levels of chloride salts**,** was early in RS-19 followed by Salt Creek and Dogridge and it was late in SO_4 and 1613-C. The possible explanation is that premature death of old leaves may be due to salts building up in the cytoplasm to toxic levels. (Schwarz, 1995). This might be among cations Na^+ and K^+ were more toxic than Ca and Mg as reported by Kishore *et al*. (1985).Irrespective of salts and rootstocks to visual symptoms were observed earlier at higher concentrations.

SUMMARY

The relative salt tolerance was assessed based on growth parameters, dry weight of root to shoot ratio, percent

reduction in growth parameters, days taken for manifestation of scorching symptoms, K/Na ratio and also on the ability of rootstocks to limit uptake of Na and Cl ions. Among different concentrations of chloride salts, significantly higher growth parameters were observed with control treatments followed by progressive decrease with increase in concentration of chloride salts was observed. In all the rootstocks there was progressive decline in the growth parameters, root parameters, K/Na ratio, root to shoot ratio and increase in sodium and chloride content with the increase in concentration of chloride salts over control. Irrespective of salts and rootstocks to visual symptoms were observed earlier at higher concentrations The order of tolerance to chloride salts by grape rootstocks was in of the order $CaCl_2$ >$MgCl_2$ > KCl >NaCl salts. Therefore based on low Cl^- content in leaves, high dry weight of root shoot ratio and high vigour Dogridge is more tolerant to salinity than other rootstocks studied.

Table 1: Effect of Varying Levels of Different Chloride Salts on Leaf Number per Plant in Different Grape Rootstocks

Rootstocks x Salts	Concentrations (meq of Cl/lt i.w.)					MEAN
	Control	4meq	8meq	16 meq	32 meq	
Dogridge x NaCl	95	93	88	79	71	**85.2**
		[2.11]	[7.37]	[16.49]	[25.26]	**[12.81]**
Dogridge x KCl	97	95	88	80	74	**86.8**
		[2.06]	[8.94]	[17.53]	[23.71]	**[13.06]**
Dogridge x $CaCl_2$	97	95	87	82	76	**87.4**
		[1.72]	[10.31]	[15.46]	[21.65]	**[12.29]**
Dogridge x $MgCl_2$	98	94	89	83	78	**88.4**
		[4.08]	[9.18]	[15.31]	[20.41]	**[12.25]**
Salt Creek x NaCl	68	60	55	42	32	**51.4**
		[11.76]	[19.12]	[38.24]	[52.94]	**[30.52]**
Salt Creek x KCl	70	66	62	53	44	**59**
		[5.71]	[11.43]	[24.29]	[37.14]	**[19.64]**
Salt Creek x $CaCl_2$	72	68	62	58	50	**62**
		[5.56]	[13.89]	[19.44]	[30.56]	**[17.36]**
Salt Creek x $MgCl_2$	76	73	69	61	55	**66.8**
		[3.95]	[9.21]	[19.74]	[27.63]	**[15.13]**
RS-19 x NaCl	80	76	69	58	45	**65.6**
		[5.00]	[13.75]	[27.50]	[43.75]	**[22.5]**
RS-19 x KCl	83	78	71	62	55	**69.8**
		[6.02]	[14.46]	[25.30]	[33.73]	**[19.88]**
RS-19 x $CaCl_2$	85	80	74	62	56	**71.4**
		[5.88]	[12.94]	[27.06]	[34.12]	**[20]**
RS-19 x $MgCl_2$	88	83	76	67	58	**74.4**
		[5.68]	[13.64]	[23.86]	[34.09]	**[19.32]**
SO4 x NaCl	90	86	74	63	54	**73.4**
		[4.44]	[17.78]	[30.00]	[40.00]	**[23.06]**
SO4 x KCl	92	87	81	74	62	**79.2**
		[5.43]	[11.96]	[19.57]	[32.61]	**[17.39]**
SO4 x $CaCl_2$	93	89	82	74	64	**80.4**
		[4.30]	[11.83]	[20.43]	[31.18]	**[16.94]**
SO4 x $MgCl_2$	94	90	84	77	68	**82.6**
		[4.26]	[10.64]	[18.09]	[27.66]	**[15.16]**
1613-C xNaCl	95	91	86	76	69	**83.4**
		[4.89]	[9.79]	[20.28]	[27.62]	**[15.66]**
1613-C x KCl	95	91	88	78	70	**84.4**
		[4.54]	[7.69]	[18.18]	[26.57]	**[14.25]**
1613-C x $CaCl_2$	96	92	86	80	74	**85.6**
		[4.17]	[10.42]	[16.67]	[22.92]	**[13.55]**
1613-C x $MgCl_2$	97	94	86	82	76	**87**
		[3.09]	[11.34]	[15.46]	[21.65]	**[12.89]**
	88	84	78	70	62	**76.4**
	CD at 5 %		**SEd±**			**[17.18]**
RxSxC	**NS**		**7.16**			

(Figures in parentheses indicate percentage reduction)

Table 2: Effect of Varying Levels of Different Chloride Salts on Shoot Length per Plant in Different Grape Rootstocks

Rootstocks x Salts	Concentrations (meq of Cl/lt i.w.				Mean
	Control	4meq	8meq	16 meq	32 meq	
Dogridge x NaCl	90.5	80.3	62	43	25	60.16
		[11.27]	[31.49]	[52.49]	[72.38]	[41.91]
Dogridge x KCl	87.9	72.5	63.7	44.7	32.7	60.3
		[17.52]	[27.53]	[49.18]	[62.83]	[39.27]
Dogridge x $CaCl_2$	93.5	77.9	70.8	52.5	32.5	65.44
		[16.69]	[24.25]	[43.80]	[65.23]	[37.49]
Dogridge x $MgCl_2$	93.7	82	81.7	59	39	71.08
		[12.45]	[12.84]	[37.03]	[58.38]	[30.18]
Salt Creek x NaCl	89.8	71.9	71.7	61.8	37.4	66.52
		[19.93]	[20.22]	[31.17]	[58.40]	[32.43]
Salt Creek x KCl	90.4	77.5	71.8	61.6	38	67.86
		[14.21]	[20.55]	[31.84]	[57.95]	[31.14]
Salt Creek x $CaCl_2$	94	83	76	54.7	45	70.54
		[11.70]	[19.15]	[41.81]	[52.10]	[31.40]
Salt Creek x $MgCl_2$	93	82	79	68	59	76.2
		[11.83]	[15.05]	[26.88]	[36.56]	[22.58]
RS-19 x NaCl	96.1	72.7	64	59.7	50.3	68.56
		[24.36]	[33.38]	[37.89]	[47.67]	[35.83]
RS-19 x KCl	94	73.5	65.9	64.7	53.8	70.38
		[21.82]	[29.90]	[31.18]	[42.72]	[31.41]
RS-19 x $CaCl_2$	92.7	74.9	72	69.7	51	72.06
		[19.23]	[22.33]	[24.84]	[44.98]	[27.85]
RS-19 x $MgCl_2$	105	98.7	69.9	67.8	57.2	79.72
		[6.00]	[33.44]	[35.44]	[45.48]	[30.09]
SO4 x NaCl	98	85.9	78	74.3	65.1	80.26
		[12.32]	[20.41]	[24.13]	[33.58]	[22.61]
SO4 x KCl	108.4	96.8	65.3	62.4	43.2	75.22
		[10.67]	[39.73]	[42.46]	[60.15]	[38.25]
SO4 x $CaCl_2$	91.9	73.2	61.2	60.9	59.9	69.42
		[20.38]	[33.43]	[33.70]	[34.84]	[30.59]
SO4 x $MgCl_2$	97	84.2	66	61.3	52.5	72.2
		[13.14]	[31.92]	[36.84]	[45.88]	[31.95]
1613-C xNaCl	84.5	70.5	54.2	51.5	45.8	61.3
		[16.27]	[35.67]	[38.85]	[45.65]	[34.11]
1613-C x KCl	89.3	86.9	69.8	66.2	56.2	73.68
		[2.63]	[21.81]	[25.80]	[36.98]	[21.81]
1613-C x $CaCl_2$	89.3	70	65.9	61.6	56.3	68.62
		[21.66]	[26.32]	[31.02]	[36.99]	[29.0]
1613-C x $MgCl_2$	84.4	74.3	63.9	60.9	51.3	66.96
		[11.94]	[24.18]	[27.78]	[39.18]	[25.77]
mean	93.16	79.43	68.63	60.31	47.56	69.8
	CD at 5 %		SEd±			[31.28]
RxSxC	NS		10.48			

(Figures in parentheses indicate percentage reduction)

Table 3: Effect of Varying Levels of Different Chloride Salts on ` Dry Weight of Shoot per Plant in Different Grape Rootstocks

Factors	**Concentrations (meq of Cl/lt i.w.**					
	Control	**4meq**	**8meq**	**16meq**	**32 meq**	
Dogridge x NaCl	43.18	40.83	37.36	35.01	29.22	**37.12**
		[5.44]	[13.48]	[18.92]	[32.33]	**[17.54]**
Dogridge x KCl	45.05	44.58	41.15	38.52	32.5	**40.36**
		[1.04]	[08.66]	[14.50]	[27.86]	**[13.02]**
Dogridge x $CaCl_2$	47.48	45.02	43.12	39.02	35.79	**42.09**
		[5.18]	[9.18]	[17.82]	[24.62]	**[14.2]**
Dogridge x $MgCl_2$	48.19	46.13	44.09	41.18	35.13	**42.94**
		[4.27]	[8.51]	[14.55]	[27.10]	**[13.61]**
Salt Creek x NaCl	42.56	39.06	36.34	33.39	28.59	**35.99**
		[8.22]	[14.61]	[21.55]	[32.82]	**[19.3]**
Salt Creek x KCl	43.24	41.12	39.43	37.02	31.29	**38.42**
		[4.90]	[8.81]	[14.38]	[27.64]	**[13.93]**
Salt Creek x $CaCl_2$	45.57	43.54	40.68	38.56	32.33	**40.136**
		[4.45]	[10.73]	[15.38]	[29.05]	**[14.90]**
Salt Creek x $MgCl_2$	46.03	44.06	42.59	39.56	34.62	**41.372**
		[4.28]	[7.47]	[14.06]	[24.79]	**[12.65]**
RS-19 x NaCl	42.03	39.6	37.69	34.43	29.92	**36.734**
		[5.78]	[10.33]	[18.08]	[28.81]	**[15.75]**
RS-19 x KCl	43.78	40.83	38.31	35.81	30.42	**37.83**
		[6.74]	[11.35]	[18.20]	[30.52]	**[16.70]**
RS-19 x $CaCl_2$	44.47	43.16	40.61	36.31	32.12	**39.334**
		[2.95]	[8.68]	[18.35]	[27.77]	**[14.44]**
RS-19 x $MgCl_2$	44.53	42.75	41.25	35.58	32.58	**39.338**
		[4.00]	[7.37]	(20.10]	[26.84]	**[14.58]**
SO4 x NaCl	42.78	40.63	35.76	33.44	30.34	**36.59**
		[3.02]	[9.86]	[13.11]	[17.46]	**[10.86]**
SO4 x KCl	43.78	41.1	38.83	35.05	31.87	**38.126**
		[3.76]	[6.95]	[12.26]	[16.72]	**[9.92]**
SO4 x $CaCl_2$	44.45	42.57	39.61	36.24	32.69	**39.112**
		[2.64]	[6.79]	[11.53]	[16.51]	**[9.37]**
SO4 x $MgCl_2$	44.68	43.01	40.22	36.98	32.83	**39.544**
		[2.34]	[6.26]	[10.81]	[16.64]	**[9.01]**
1613-C xNaCl	42.01	40.62	37.68	34.47	30.54	**37.064**
		[1.95]	[6.08]	[10.59]	[16.10]	**[8.68]**
1613-C x KCl	43.56	41.19	39.3	37.59	31.21	**38.57**
		[3.33]	[5.98]	[8.38]	[17.34]	**[8.76]**
1613-C x $CaCl_2$	44.65	43.18	39.32	37.16	32.15	**39.292**
		[2.06]	[7.48]	[10.52]	[17.55]	**[9.40]**
1613-C x $MgCl_2$	44.79	42.54	39.8	36.96	32.96	**39.41**
		[3.16]	[7.01]	[10.99]	[16.61]	**[9.44]**
mean	**44.34**	**42.28**	**39.66**	**36.61**	**31.96**	**38.97**

(Figures in parentheses indicate percentage reduction)

Table 4: Effect of Varying Levels of Different Chloride Salts on Average Number of Roots per Plant in Different Grape Rootstocks

Rootstocks x Salts	Concentrations (meq of Cl/lt i.w.)					MEAN
	Control	4meq	8meq	16 meq	32 meq	
Dogridge x NaCl	82.1	78.6	61.7	38.7	15.1	55.24
		[4.26]	[24.78]	[52.85]	[81.56]	[40.86]
Dogridge x KCl	83.5	77.2	65	47.5	23.6	59.36
		[7.51]	[22.16]	[43.09]	[71.73]	[36.12]
Dogridge x $CaCl_2$	84.5	76.3	66.2	50.4	26.5	60.78
		[9.71]	[21.66]	[40.37]	[68.66]	[35.18]
Dogridge x $MgCl_2$	83.7	79.4	70.3	59.8	25.9	63.82
		5.14	16.08	28.54	69.1	[23.77]
Salt Creek x NaCl	64.8	56.9	44.3	33.4	14.2	42.72
		[12.19]	[31.59]	[48.46]	[78.04]	[42.57]
Salt Creek x KCl	65.2	55.3	49.3	32.5	23.5	45.16
		[15.18]	[24.34]	[50.15]	[63.96]	[38.41]
Salt Creek x $CaCl_2$	65.3	56.6	42.5	35.6	24.8	44.96
		[13.28]	[34.96]	[45.48]	[62.07]	[38.95]
Salt Creek x $MgCl_2$	66.4	58.9	49.5	36.4	24.4	47.12
		[11.25]	[25.50]	[45.14]	[63.25]	[36.29]
RS-19 x NaCl	67.5	59.5	43.3	32.1	23.2	45.12
		[11.81]	[35.90]	[52.40]	[65.59]	[41.43]
RS-19 x KCl	68.4	58.7	46.9	35.4	22.4	46.36
		[14.22]	[31.42]	[48.31]	[67.31]	[40.32]
RS-19 x $CaCl_2$	69.3	60.8	52.4	39.6	24.6	49.34
		[12.27]	[24.43]	[42.90]	[64.50]	[36.03]
RS-19 x $MgCl_2$	68.7	62.4	54.8	38.3	25.7	49.98
		[9.21]	[20.23]	[44.29]	[62.59]	[34.08]
SO4 x NaCl	68.4	60.3	48.5	35.5	23.9	47.32
		[11.84]	[29.14]	[48.06]	[65.01]	[38.51]
SO4 x KCl	67.4	59.8	47.4	36.7	26.6	47.58
		[11.32]	[29.66]	[45.62]	[60.51]	[36.78]
SO4 x $CaCl_2$	69.4	63.9	52.5	43.7	26.5	51.2
		[8.11]	[25.02]	[38.07]	[63.58]	[33.70]
SO4 x $MgCl_2$	68.8	62.4	53.7	46.4	27.6	51.78
		[9.35]	[21.99]	[32.51]	[59.93]	[30.95]
1613-C xNaCl	69.5	60.9	52.5	31.8	21.6	47.26
		[12.37]	[24.50]	[54.20]	[68.88]	[39.99]
1613-C x KCl	70.3	67.3	56.4	43.6	25.7	52.66
		[4.22]	[19.77]	[37.94]	[63.49]	[31.36]
1613-C x $CaCl_2$	70.7	68.7	55.5	46.3	26.7	53.58
		[2.79]	[21.42]	[34.44]	[62.18]	[30.21]
1613-C x $MgCl_2$	71.2	69.6	56.5	48.4	27.3	54.6
		[2.25]	[20.64]	[32.05]	[61.67]	[29.15]
Mean	71.3	64.7	53.5	40.6	24	50.82
	CD at 5 %		SEd±			[35.73]
RxSxC	NS		4.46			

(Figures in parentheses indicate percentage reduction)

Table 5: Effect of Varying Levels of Different Chloride Salts on `Average Length Root per Plant in Different Grape Rootstocks

Rootstocks x Salts	Concentrations (meq of Cl/lt i.w.)					MEAN
	Control	4meq	8meq	16 meq	32 meq	
Dogridge x NaCl	61.2	54.7	43.7	34.9	15.7	**42.04**
		[10.57]	[28.55]	[42.92]	[74.35]	**[39.10]**
Dogridge x KCl	64.3	55.1	44.9	35.8	16.2	**43.26**
		[14.26]	[30.12]	[44.32]	[74.85]	**[40.89]**
Dogridge x $CaCl_2$	63.7	56.1	45.3	33.7	16.9	**43.14**
		[11.93]	[28.87]	[47.17]	[73.43]	**[40.35]**
Dogridge x $MgCl_2$	64.3	55.9	45.7	34.7	14.2	**42.96**
		[13.11]	[28.88]	[45.99]	[77.95]	**[41.48]**
Salt Creek x NaCl	60.8	53.4	43.9	26.7	11.5	**39.26**
		[12.13]	[27.72]	[56.02]	[81.10]	**[44.24]**
Salt Creek x KCl	63.7	53.5	43.7	34.3	15.2	**42.08**
		[16.05]	[31.32]	[46.22]	[76.07]	**[42.42]**
Salt Creek x $CaCl_2$	63.3	54.4	42.9	33.9	16.1	**42.12**
		[14.01]	[32.31]	[46.41]	[74.64]	**[41.84]**
Salt Creek x $MgCl_2$	64.1	55.2	44.5	34.4	13.7	**42.38**
		[13.80]	[30.56]	[46.36]	[78.54]	**[42.32]**
RS-19 x NaCl	59.7	44.1	36.2	24.3	12.5	**35.36**
		[26.04]	[39.33]	[59.33]	[79.14]	**[50.96]**
RS-19 x KCl	60.3	51.7	42.5	36.3	13.5	**40.86**
		[14.19]	[29.53]	[39.70]	[77.53]	**[40.24]**
RS-19 x $CaCl_2$	60.4	53.8	40.4	31.9	15.8	**40.46**
		[10.91]	[33.18]	[47.20]	[73.83]	**[41.28]**
RS-19 x $MgCl_2$	61.2	53.6	39.1	27.8	16.4	**39.62**
		[12.35]	[36.01]	[54.54]	[73.13]	**[44.01]**
SO4 x NaCl	58.7	46.7	38.8	29.6	14.4	**37.64**
		[20.43]	[33.84]	[49.53]	[75.38]	**[44.80]**
SO4 x KCl	59.3	48.8	39.5	28.6	16.4	**38.52**
		[17.76]	[33.39]	[51.77]	[72.29]	**[43.80]**
SO4 x $CaCl_2$	60.1	53.5	41.7	30.4	17.4	**40.62**
		[11.03]	[30.62]	[49.43]	[71.10]	**[40.55]**
SO4 x $MgCl_2$	60.4	53.6	42.7	31.1	18.2	**41.2**
		[11.34]	[29.32]	[48.49]	[69.97]	**[39.78]**
1613-C xNaCl	59.5	46.5	35.2	21.2	13.7	**35.22**
		[21.86]	[40.85]	[64.31]	[77.05]	**[34.52]**
1613-C x KCl	60.5	51.1	40.9	28.4	15.8	**39.34**
		[15.47]	[32.39]	[53.00]	[73.83]	**[43.67]**
1613-C x $CaCl_2$	61	53.6	42.6	31.4	17.8	**41.28**
		[12.13]	[30.25]	[48.55]	[70.83]	**[40.44]**
1613-C x $MgCl_2$	61.5	53.3	43.4	32.6	17.9	**41.74**
		[13.34]	[29.48]	[46.97]	[70.83]	**[40.16]**
Mean	61.4	52.4	41.9	31.1	15.5	**40.46**
	CD at 5 %		**SEd±**			**[41.84]**
RxSxC	NS		5.91			

(Figures in parentheses indicate percentage reduction)

Table 6: Effect of Varying Levels of Different Chloride Salts on `Root Volume per Plant in Different Grape Rootstocks

Rootstocks x Salts	Concentrations (meq of Cl/lt i.w.)					MEAN
	Control	4meq	8meq	16 meq	32 meq	
Dogridge x NaCl	150	120	90	70	30	**92**
		[20]	[40]	[53.3]	[80]	**[48.3]**
Dogridge x KCl	150	110	90	70	40	**92**
		[27]	[40]	[53]	[73]	**[48.3]**
Dogridge x $CaCl_2$	170	130	90	70	50	**102**
		[24]	[47]	[59]	[71]	**[50.3]**
Dogridge x $MgCl_2$	180	140	110	90	60	**116**
		[22]	[39]	[50]	[67]	**[44.5]**
Salt Creek x NaCl	130	100	90	70	20	**82**
		[23]	[31]	[46]	[85]	**[46.3]**
Salt Creek x KCl	180	150	110	90	60	**118**
		[17]	[39]	[50]	[67]	**[43.3]**
Salt Creek x $CaCl_2$	150	110	90	70	50	**94**
		[27]	[40]	[53]	[67]	**[46.8]**
Salt Creek x $MgCl_2$	160	140	130	110	90	**126**
		[13]	[19]	[31]	[44]	**[26.8]**
RS-19 x NaCl	150	120	70	50	30	**84**
		[20]	[53]	[67]	[80]	**[55]**
RS-19 x KCl	170	150	120	90	50	**116**
		[12]	[29]	[47]	[71]	**[39.8]**
RS-19 x $CaCl_2$	160	150	130	90	60	**118**
		[6]	[19]	[44]	[63]	**[33]**
RS-19 x $MgCl_2$	190	170	140	110	80	**138**
		[11]	[26]	[42]	[58]	**[34.3]**
SO4 x NaCl	130	110	90	70	50	**90**
		[15]	[31]	[46]	[62]	**[38.5]**
SO4 x KCl	150	130	110	80	60	**106**
		[13]	[27]	[47]	[60]	**[36.8]**
SO4 x $CaCl_2$	160	150	120	110	80	**124**
		[6]	[25]	[31]	[50]	**[28]**
SO4 x $MgCl_2$	170	150	130	110	90	**130**
		[12]	[24]	[35]	[47]	**[29.5]**
1613-C xNaCl	130	110	90	60	30	**84**
		[15]	[31]	[54]	[77]	**[44.3]**
1613-C x KCl	140	120	100	80	40	**96**
		[14]	[29]	[43]	[71]	**[39.3]**
1613-C x $CaCl_2$	150	130	100	80	60	**104**
		[13]	[33]	[47]	[60]	**[38.3]**
1613-C x $MgCl_2$	160	140	120	90	80	**118**
		[13]	[25]	[44]	[50]	**[33]**
Mean	157	132	106	83	56	**106.8**
	CD at 5 %		**SEd±**			**[40.19]**
RxSxC	**NS**		**25.83**			

(Figures in parentheses indicate percentage reduction)

Table 7: Effect of Varying Levels of Different Chloride Salts on `Dry Weight of Root per Plant in Different Grape Rootstocks

Rootstocks x salts	Concentrations (meq of Cl/lt i.w.					Mean
	Control	4meq	8meq	16 meq	32 meq	
Dogridge x NaCl	36.11	23.49	20.34	18.31	7.5	**21.15**
		[34.95]	[43.67]	[49.29]	[79.23]	**[51.79]**
Dogridge x KCl	37.24	29.07	24.49	20.1	10.32	**24.244**
		[21.94]	[34.24]	[46.03]	[72.29]	**[43.63]**
Dogridge x $CaCl_2$	38.92	29.53	26.06	21.81	12.96	**25.856**
		[24.13]	[33.04]	[43.96]	[66.70]	**[41.96]**
Dogridge x $MgCl_2$	39.45	30.13	27.5	22.52	14.31	**26.782**
		[23.62]	[30.29]	[42.92]	[63.73]	**[40.14]**
Salt Creek x NaCl	27.17	23.63	15.8	13.4	6.8	**17.36**
		[13.03]	[41.85]	[50.68]	[74.97]	**[45.13]**
Salt Creek x KCl	28.83	24.6	18.17	15.3	8.82	**19.144**
		[14.67]	[36.98]	[46.93]	[69.41]	**[42.0]**
Salt Creek x $CaCl_2$	30.57	25.6	21.43	16.63	11.1	**21.066**
		[16.26]	[29.90]	[45.60]	[63.69]	**[38.86]**
Salt Creek x $MgCl_2$	30.77	27.7	25.4	18.3	13.4	**23.114**
		[9.98]	[17.45]	[40.53]	[56.45]	**[31.10]**
RS-19 x NaCl	33.53	22.13	17.48	12.71	5.3	**18.23**
		[34.00]	[47.87]	[62.09]	[84.19]	**[57.04]**
RS-19 x KCl	34.27	26.43	18.54	14.89	8.07	**20.44**
		[22.88]	[45.90]	[56.55]	[76.45]	**[50.45]**
RS-19 x $CaCl_2$	34.97	28.1	26.4	19.7	10.37	**23.908**
		[19.65]	[24.51]	[43.67]	[70.35]	**[39.55]**
RS-19 x $MgCl_2$	34.74	28.4	25.16	21.4	12.2	**24.38**
		[18.25]	[27.58]	[38.40]	[64.88]	**[37.28]**
SO4 x NaCl	31.4	26.77	19.5	16.8	9.8	**20.854**
		[14.75]	[37.90]	[46.50]	[68.79]	**[41.99]**
SO4 x KCl	32.7	25.5	18.87	14.72	10.36	**20.43**
		[22.02]	[42.29]	[54.98]	[68.32]	**[47.02]**
SO4 x $CaCl_2$	32.83	27.58	22.27	16.08	12.5	**22.252**
		[15.99]	[32.17]	[51.02]	[61.93]	**[40.28]**
SO4 x $MgCl_2$	33.13	28.13	23.5	19.63	11.77	**23.232**
		[15.09]	[29.07]	[40.75]	64.47	**[37.35]**
1613-C xNaCl	25.17	21.17	18.23	14.36	8.57	**17.5**
		[15.89]	[27.57]	[42.95]	[65.95]	**[38.09]**
1613-C x KCl	26.45	22.47	19.81	15.07	11.2	**19**
		[15.05]	[25.10]	[43.02]	[57.66]	**[35.21]**
1613-C x $CaCl_2$	27.27	23.26	20.17	16.53	12.9	**20.026**
		[14.70]	[26.04]	[39.38]	[52.70]	**[33.21]**
1613-C x $MgCl_2$	27.35	25.17	21.9	18.27	13.47	**21.232**
		[7.97]	[19.93]	[33.20]	[50.75]	**[27.96]**
mean	32.14	25.94	21.55	17.33	10.59	**21.51**
	CD at 5 %		**SEd±**			**[41]**
RxSxC	**NS**		**5.43**			

(Figures in parentheses indicate percentage reduction)

Table 8: Effect of Varying Levels of Different Chloride Salts on ` Root: Shoot Ratio in Different Grape Rootstocks

Factors	Concentrations (Meq of Cl/lt i.w.)					
	Control	4 Meq of Cl	8 Meq of Cl	16 Meq of Cl	32 Meq of Cl	Mean
Dogridge x NaCl	0.83	0.58	0.55	0.51	0.25	**0.5**
Dogridge x KCl	0.83	0.65	0.59	0.52	0.32	**0.6**
Dogridge x $CaCl_2$	0.81	0.66	0.59	0.55	0.36	**0.6**
Dogridge x $MgCl_2$	0.82	0.64	0.61	0.54	0.4	**0.6**
Salt Creek x NaCl	0.63	0.6	0.43	0.39	0.23	**0.5**
Salt Creek x KCl	0.66	0.59	0.46	0.41	0.27	**0.5**
Salt Creek x $CaCl_2$	0.67	0.59	0.53	0.42	0.37	**0.5**
Salt Creek x $MgCl_2$	0.66	0.64	0.62	0.46	0.39	**0.6**
RS-19 x NaCl	0.81	0.58	0.47	0.37	0.17	**0.5**
RS-19 x KCl	0.8	0.66	0.48	0.43	0.27	**0.5**
RS-19 x $CaCl_2$	0.81	0.68	0.65	0.55	0.31	**0.6**
RS-19 x $MgCl_2$	0.8	0.68	0.63	0.59	0.35	**0.6**
SO4 x NaCl	0.76	0.66	0.53	0.49	0.31	**0.6**
SO4 x KCl	0.75	0.62	0.47	0.41	0.31	**0.5**
SO4 x $CaCl_2$	0.74	0.65	0.56	0.46	0.36	**0.6**
SO4 x $MgCl_2$	0.76	0.65	0.59	0.53	0.35	**0.6**
1613-C xNaCl	0.6	0.51	0.49	0.41	0.26	**0.5**
1613-C x KCl	0.61	0.54	0.49	0.41	0.38	**0.5**
1613-C x $CaCl_2$	0.62	0.55	0.54	0.44	0.38	**0.5**
1613-C x $MgCl_2$	0.63	0.6	0.55	0.52	0.4	**0.5**
Mean	0.73	0.62	0.54	0.47	0.32	**0.5**
			CD		**SEd ±**	
Rootstocks X Salts X Concentrations			**NS**		**0.07**	

Table 9: Percent Reduction in Root Parameters of Different Grape Rootstocks Due to Chloride Salts

NaCl						
	Dogridge	Salt Creek	RS-19	SO4	1613-C	MEAN
average number of roots per vine	32.8	34.1	33.2	30.8	31.9	**32.6**
average length of roots per vine	31.2	35.4	40.9	35.9	40.8	**36.8**
root volume per vine	38.7	36.9	44.0	30.8	35.4	**37.1**
dry weight of roots per vine	40.2	36.0	45.7	33.4	30.6	**37.2**
MEAN	**35.73**	**35.60**	**40.95**	**32.73**	**34.68**	**35.93**
KCl						
average number of roots per vine	28.9	30.7	32.2	29.4	32.7	**30.8**
average length of roots per vine	32.7	33.9	32.2	35.1	34.9	**33.7**
root volume per vine	38.7	34.4	31.8	29.3	31.4	**33.1**
dry weight of roots per vine	34.9	32.6	40.5	37.6	28.3	**34.8**
MEAN	**33.8**	**32.9**	**34.2**	**32.8**	**31.8**	**33.1**
CaCl2						
average number of roots per vine	28.0	31.1	28.9	26.2	24.2	**27.7**
average length of roots per vine	32.2	33.5	32.9	32.4	32.3	**32.7**
root volume per vine	40.0	37.3	26.3	22.5	30.7	**31.4**
dry weight of roots per vine	33.4	31.0	31.7	32.0	26.7	**31.0**
MEAN	**33.4**	**33.3**	**29.9**	**28.2**	**28.5**	**30.7**
MgCl2						
average number of roots per vine	23.8	29.1	34.5	24.7	23.3	**27.1**
average length of roots per vine	33.1	33.9	35.3	31.8	32.2	**33.3**
root volume per vine	35.6	21.3	27.4	23.5	26.3	**26.8**
dry weight of roots per vine	32.2	25.0	29.7	29.9	22.6	**27.9**
MEAN	**31.2**	**27.3**	**31.7**	**27.5**	**26.1**	**28.8**

Table 10: Days for Manifestation of Injury Due to Varying Level of Nacl Salinity in Grape Rootstocks

NaCl										
Levels meq of Cl/lt	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**
	Dogridge					**Salt Creek**				
Control										
4meq	69	78	91			65	74	86		
8meq	59	67	75	85		59	67	76	82	
16meq	48	54	66	74	80	80	56	64	70	76
32meq	43	46	53	66	73	38	47	56	64	70
	RS-19					**SO_4**				
Control										
4meq	63	71	83			98	112	119		
8meq	57	63	70	78		88	99	106	116	
16meq	41	48	53	53	67	79	86	103	109	113
32meq	35	41	47	52	59	66	78	89	97	109
	1613-C									
Control										
4meq	68	80	92							
8meq	60	71	57	90						
16meq	54	62	69	77	85					
32meq	49	57	66	72	78					
KCl										
	Dogridge					**Salt Creek**				
Control										
4meq	76	87	102			77	92	106		
8meq	67	80	91	97		65	83	91	100	
16meq	60	71	81	89	93	61	73	82	91	97
32meq	56	68	79	86	90	54	66	77	85	93
	RS-19					**SO_4**				
Control										
4meq	69	80	91			71	84	95		
8meq	63	71	80	88		64	71	81	89	
16meq	55	67	75	82	86	58	68	77	82	86
32meq	42	51	66	74	82	51	60	68	75	83
	1613-C									
Control										
4meq	79	97	112							
8meq	72	88	96	107						
16meq	68	79	87	94	99					
32meq	56	76	84	89	95					
$CaCl_2$										
Levels meq of Cl/lt	**S1**	**S2**	**S3**	**S4**	**S5**	**S1**	**S2**	**S3**	**S4**	**S5**
	Dogridge					**Salt Creek**				
Control										
4meq	89	106	118			82	94	109		
8meq	82	99	108	113		77	89	97	106	
16meq	76	87	98	105	110	70	80	87	96	102
32meq	72	83	89	97	105	66	75	83	92	98
	RS-19					**SO_4**				
Control										
4meq	86	97	114			92	110	120		
8meq	79	88	98	108		87	99	114	117	
16meq	73	83	89	99	106	78	89	98	105	111
32meq	69	79	85	95	101	69	78	87	97	106
	1613-C									

Table 10: Contd.,										
Control										
4meq	96	109	121							
8meq	89	98	110	118						
16meq	79	88	104	109	115					
32meq	68	79	89	98	109					
$MgCl_2$										
	Dogridge					**Salt Creek**				
Control										
4meq	98	112	119			90	113	120		
8meq	88	99	106	116		84	99	112	117	
16meq	79	86	103	109	113	76	89	100	106	115
32meq	66	78	89	97	109	64	79	91	97	111
	RS-19					**SO_4**				
Control										
4meq	88	110	119			94	111	116		
8meq	78	97	115	118		86	98	106	114	
16meq	67	88	109	113	116	76	89	102	108	110
32meq	58	77	92	98	105	57	77	86	95	107
1613-C										
Control										
4meq	94	115	123							
8meq	87	100	111	120						
16meq	78	88	103	112	117					
32meq	56	78	92	100	113					

S1 = initiation of scorching

S2 = < 25 per cent scorching

S3 = 26 to 50 per cent scorching

S4 = 51 to 75 per cent scorching

S5 = > 75 per cent scorching

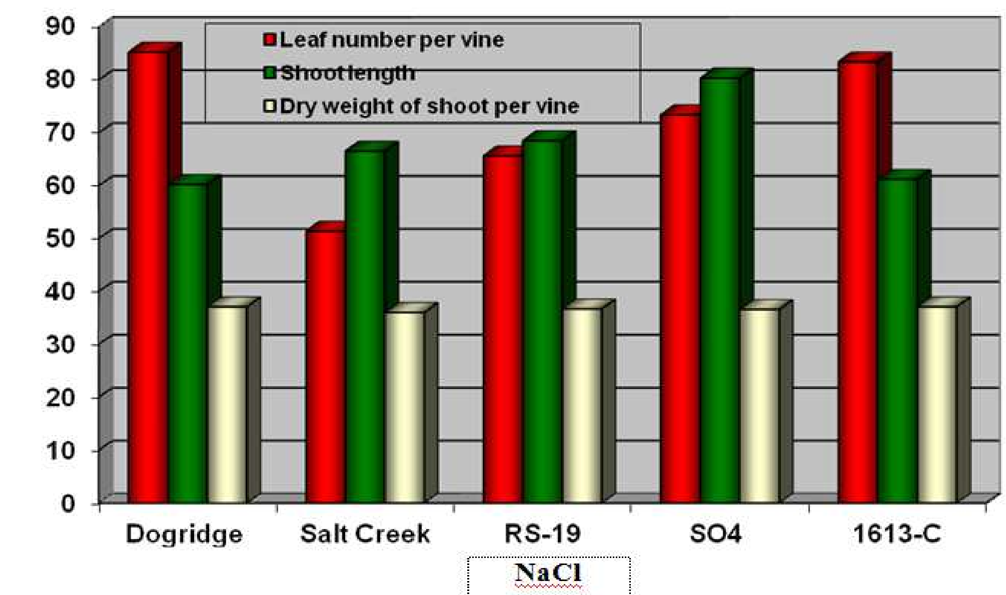

Figure 1: Percentage Reduction in Growth Parameters of Different Grape Rootstocks Due to Nacl Salt

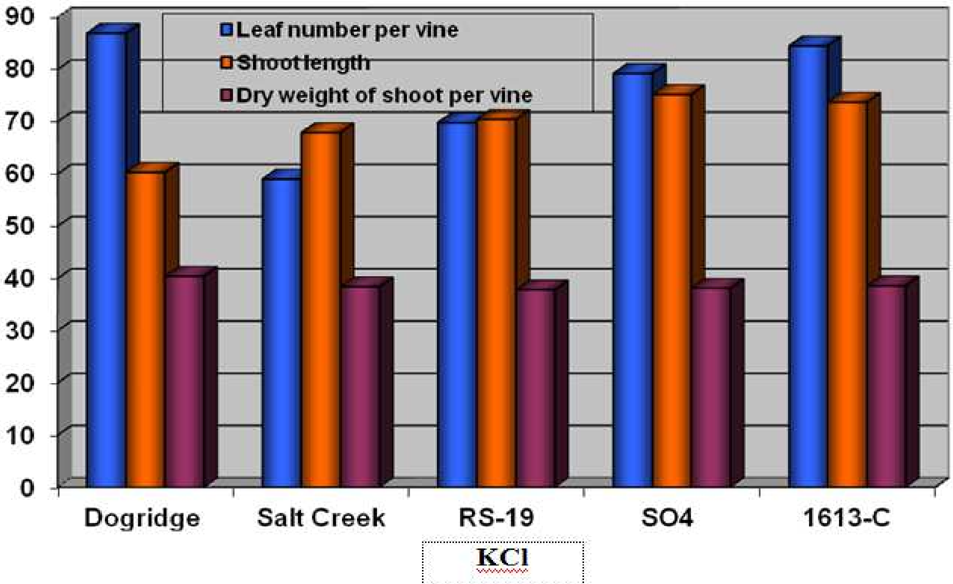

Figure 2: Percentage Reduction in Growth Parameters of Different Grape Rootstocks Due to Kcl Salt

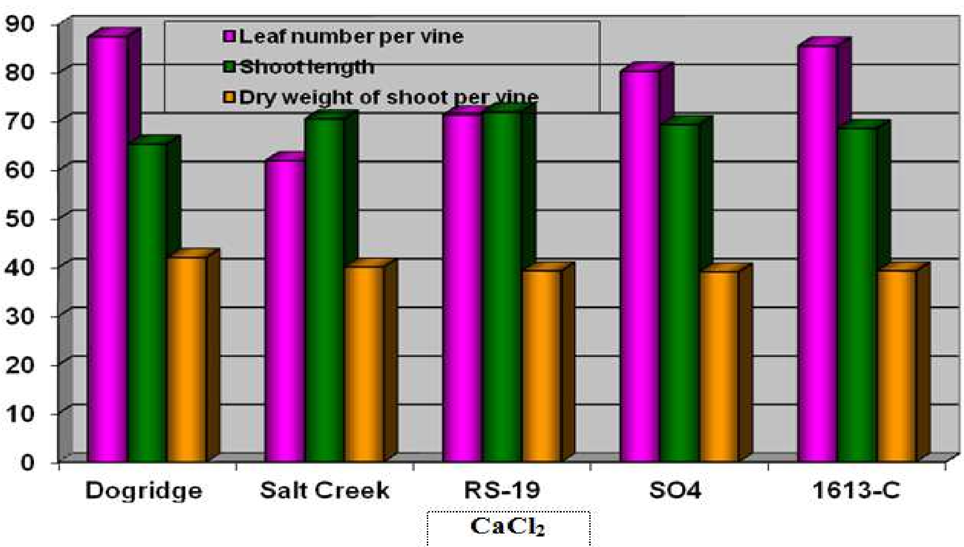

Figure 3: Percentage Reduction in Growth Parameters of Different Grape Rootstocks Due to $Cacl_2$ Salt

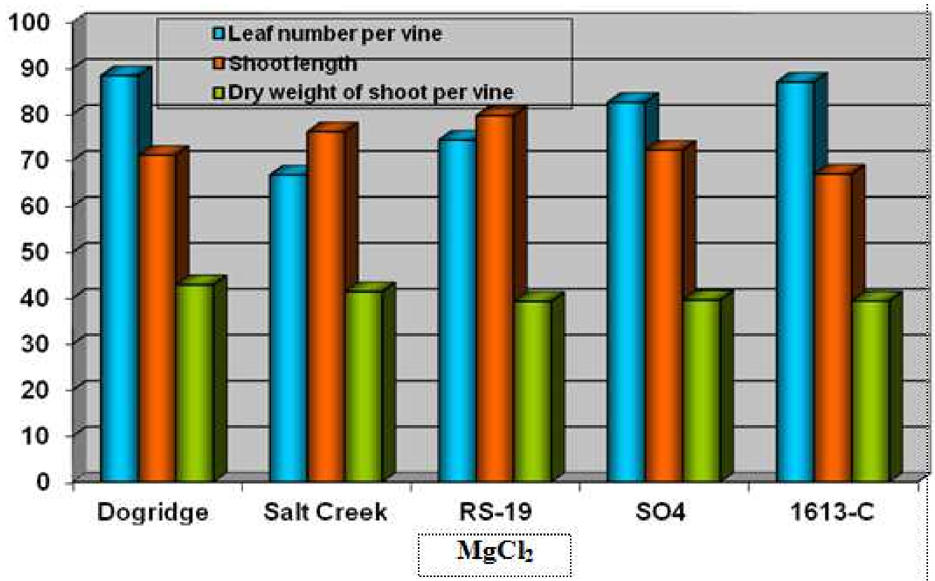

Figure 4: Percentage Reduction in Growth Parameters of Different Grape Rootstocks Due to Mgcl$_2$ Salt

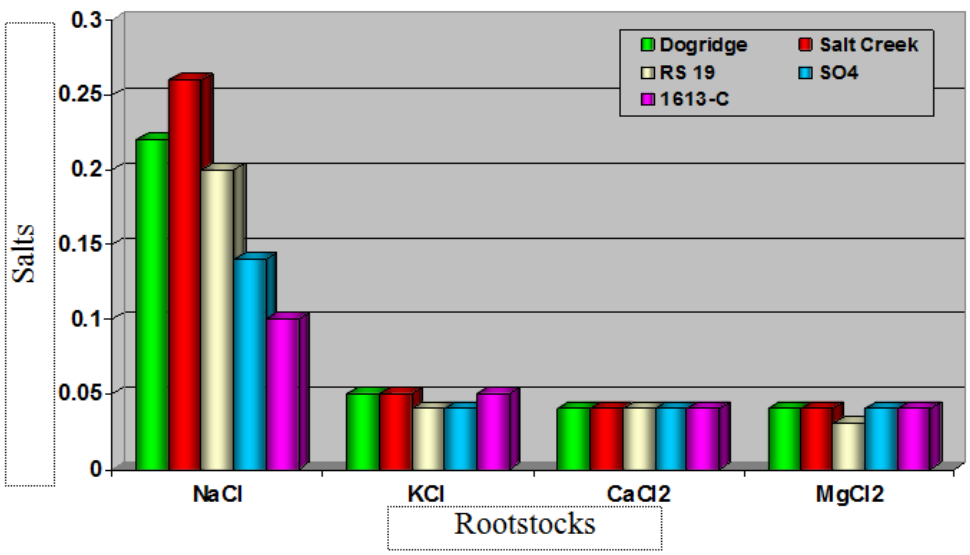

Figure 5: Effect of Different Chloride Salts on `Na' Content (%) in Leaf in Different Grape Rootstocks

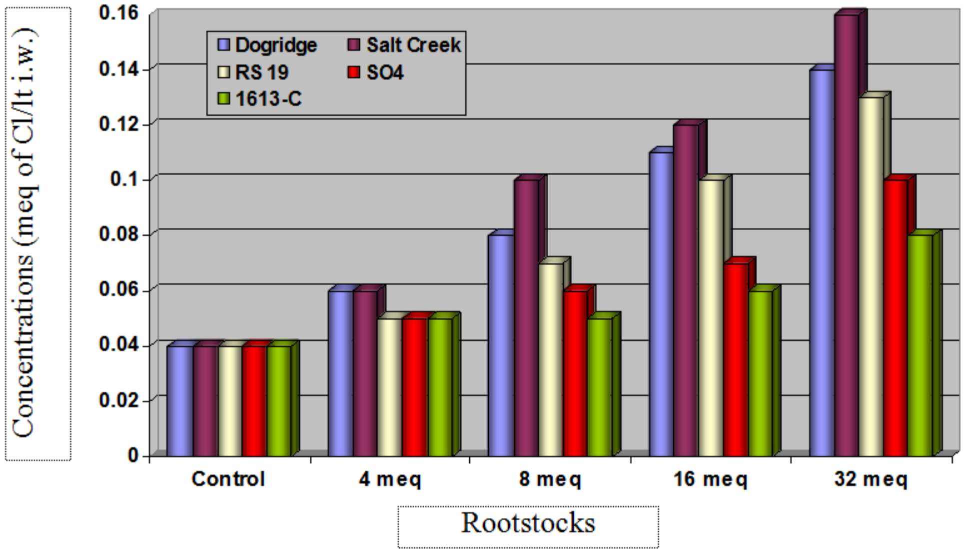

Figure 6: Effect of Varying Levels of Different Chloride Salts on `Na' Content (%) in Leaf in Different Grape Rootstocks

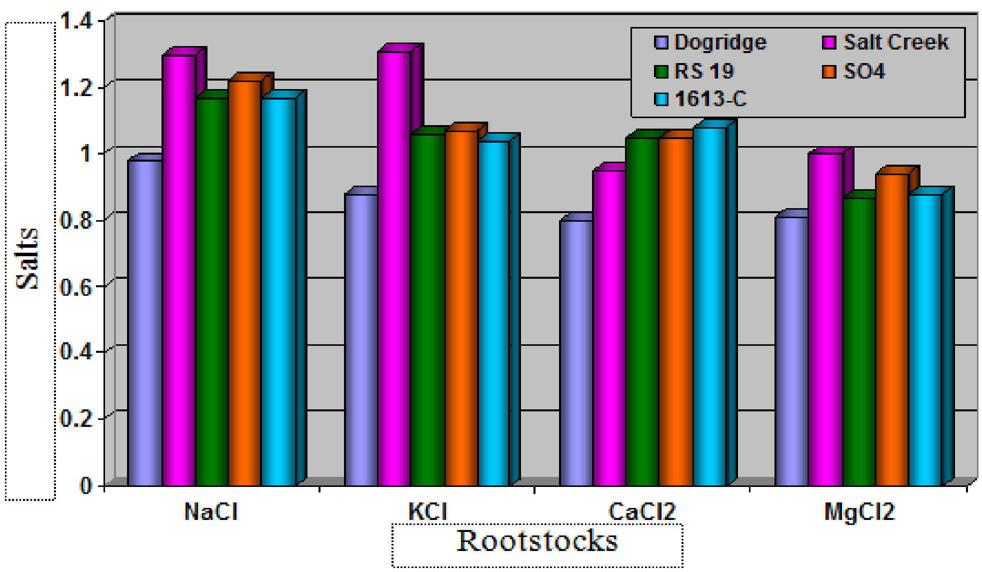

Figure 7: Effect of Different Chloride Salts on `Cl Content (%)' in Different Grape Rootstocks

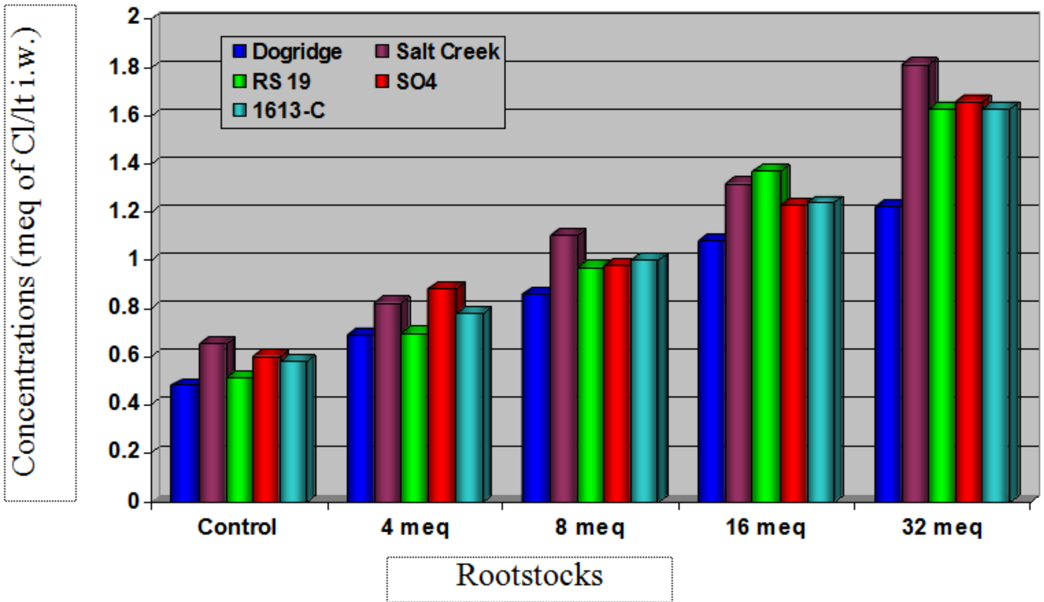

Figure 8: Effect of Varying Levels of Different Chloride Salts on `Cl Content (%) in Leaf in Different Grape Rootstocks

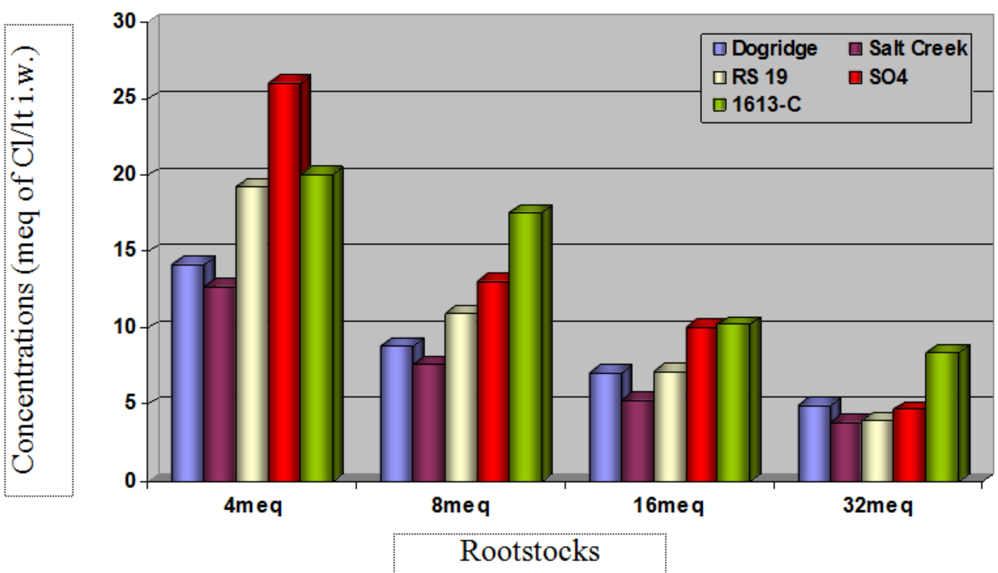

Figure 9: Effect of Varying Levels of Different Chloride Salts on `K/Na' Content (%) in Leaf in Different Grape Rootstocks

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